Trophic Relationships in the Water Hyacinth Community

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Since its introduction to Florida in 1835 (Goin, 1943), the water hyacinth, *Eichhornia crassipes* (Mart.) Solms, has been considered both a blessing and a curse. From the negative standpoint, the rapid growth of this mat-forming species serves as a menace to navigation, irrigation, drainage, and flood-control through sheer blockage. Eradication of the hyacinth has proved both difficult and expensive. On the positive side, this floating form with its extensive arborescent root mass provides a natural shelter and microhabitat which abounds in a rich associated fauna. Some naturalists are now advocating retaining a controlled border of hyacinths because of its support of game fishes and their food organisms.

The purpose of the present study was to make a preliminary investigation of some of the trophic relationships between the vertebrate and invertebrate members of the hyacinth community. It was the intent of the study to establish some food chains using varying techniques including a radioactive tracer (P-32), stomach analyses, and direct feeding observation.

One critical question asked was whether the hyacinth itself contributed as a significant producer in the food web. A second specific problem involved the precise role of the talitrid amphipod, *Hyalella azteca.*

Materials and Methods

Biota. Larger animals used in the study were collected in 10 and 15 foot minnow-seines from marginally located hyacinths in shallow water of the St. Johns River and its tributaries. Amphipod crustaceans (scuds), *Hyalella azteca,* were easily taken by rapidly plunging the roots of a hyacinth plant up and down in a small bucket of water. Small hyacinths bearing 6-10 leaves were selected for feeding and isotope experimentation.

Radiological Techniques. The general procedure for this aspect of the study was to introduce the radionuclide, phosphorus-32, in aqueous solution to both hyacinths and scuds. Both forms showed a rapid uptake of the isotope as soon as 24 hours. These two species were used as the starting point for the majority of feeding experiments. For isotope counting, experimental animals were sectioned into pre-weighed planchets, dried thoroughly under an infra-red lamp, and ashed in an oven at 600 C. The ash was weighed and then counted by a beta-scintillation detector.

Feeding Experimentation. The laboratory studies were conducted with invertebrate and vertebrate species in small aquaria and plastic containers. Experimental forms were separated from controls by hardware cloth covered with 1 mm mesh nylon. Aeration was used for those species requiring high oxygen tension. Feeding experimentation in the field employed flow-through cages constructed of a wooden frame ($3 \times 2 \times 2$ feet) enclosed by aluminum screen and 1 mm nylon-mesh cloth. These cages were used in a protected area of the St. John's River.

Results

The study consisted of two major portions, namely the laboratory investigation and a field endeavor. Laboratory studies were primarily concentrated upon individual feeding experimentation on hyacinth roots or scuds. In the field operation varying species combinations were placed in the cages to determine differing feeding interactions.

Radioactive Tracer Evidence. The radiological criteria for establishing certain species as definite hyacinth or scud feeders was based upon sufficient numbers of laboratory and field tests showing significantly higher P-32 levels in the experimental as contrasted to the control groups. Strongly reliable radiological evidence for four herbivorous species feeding upon hyacinth roots is presented in Table 1. Table 2 offers good evidence that four primary carnivore

TABLE 1

Phosphorus-32 levels in *Eichhornia crassipes* feeders

Species	Laboratory		Field	
	No. Tests	Av. $\times 10^{-3} \mu c/gm$ (controls=0.0)	No. Tests	Av. $\times 10^{-3} \mu c/gm$ (controls=0.0)
Hyalella azteca	6	412.3	2	331.0
Procambarus fallax	1	11.6	3	43.3
Pomacea paludosa	1	15.1	3	23.2
Hyla cinerea cinerea (tadpole)	—	—	1	360.0

TABLE 2

Phosphorus-32 levels in *Hyalella azteca* feeders

Species	Laboratory		Field	
	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)
Ictalurus nebulosus marmoratus	3	13.0	2	21.4
Lepomis punctatus punctatus	4	22.7	3	20.4
Lepomis macrochirus purpurescens	5	24.7	2	22.3
Enneacanthus gloriosus	10	37.9	2	12.6

TABLE 3

Phosphorus-32 levels in possible *Hyalella axteca* feeders

Species	Laboratory		Field	
	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)	No. Tests	Av.$\times 10^{-3}\mu c/gm$ (controls=0.0)
Palaemonetes paludosus	5	7.3	1	0.5
Procambarus fallax	5	8.7	3	1.9
Ranatra fusca	8	2.4	2	22.5
Anisoptera larva	5	16.4	—	—
Lucania goodei	3	17.4	1	38.2
Fundulus chrysotus	2	2.7	1	6.3
Mollienesia latipinna	1	39.1	—	—
Pomoxis nigromaculatus	5	16.4	—	—

piscine species feed upon the scud. Table 3 suggests a carnivorous role for eight forms, but additional study is needed to confirm these forms as certain scud feeders. In the tabular presentation, distinction is made between the laboratory and field situation.

Stomach Analysis and Observation. Some data were obtained from limited stomach analyses as shown in Table 4. Direct observation of aquarium feeding showed that the stumpknocker (*Lepomis punctatus punctatus*) and southern brown bullhead (*Ictalurus nebulosus marmoratus*) captured scuds in the open water. The stumpknocker was quite adept at catching scuds. Water scorpions (*Ranatra fusca*) and an unidentified anisopteran larva were ob-

TABLE 4
Stomach analyses

Individuals Examined	Species	Significant stomach contents
20	*Fundulus chrysotus*	1 anisopteran larva; 1 scud; small aquatic beetles; unidentified arthropod parts
10	*Gambusia affinis holbrooki*	3 with desmids & blue-green algae; beetle larva; unidentified arthropod parts
6	Anisopteran larva	Unidentified arthropod parts
1	*Chaenobryttus coronarius*	Small fish remains
2	*Lepomis p. punctatus*	1 freshwater shrimp; small aquatic beetles
1	*Lepomis macrochirus purpurescens*	1 freshwater shrimp

served attempting to capture scuds, but the amphipods often escaped the grasping limbs and mouth parts.

Discussion

A partial food web (Fig. 1) has been constructed as a composite from all data collected in the study. It is incomplete as concerns

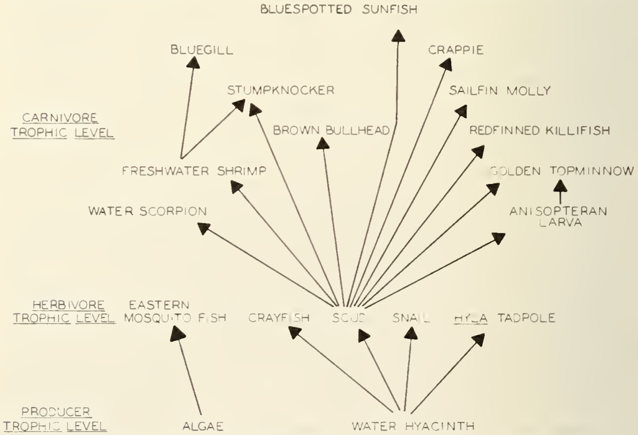

Fig. 1. Partial food-web suggested for the water hyacinth community from P-32 evidence and stomach analyses.

the total feeding relationships of the total hyacinth community. Although micro-producers as phytoplankton undoubtedly play a role in the nutrition of some members of the hyacinth community, phytoplankton has not been considered in the present study.

Producer Trophic Level. Although the water hyacinth is certainly the major macro-producer in the community, other occasional associates would include such floaters as water lettuce (*Pistia stratiotes*), water fern (*Salvinia rotundifolia*), and duckweeds (*Lemna minor, Spirodela polyrhiza*); submergents as water milfoil (*Myriophyllum* sp.) and alligator weed (*Alternanthera philoxeroides*); and emergents as cattail (*Typha latifolia*), pickeral weed (*Pontederia lanceolata*), and grasses.

Herbivore Trophic Level. The principal herbivore of the hyacinth community, feeding specifically upon hyacinth roots, is the scud (*Hyalella azteca*). Numerically, the scud is the dominant metazoan animal in the water hyacinth community as also verified by the studies of Katz (1967) and O'Hara (1967). From a total of 32 hyacinth plants examined, an average number of 66 scuds per hyacinth was counted. Amphipods are generally recognized to be detritus feeders or scavengers (Barnes, 1968). Although we have observed *Hyalella* feeding upon normal hyacinth root tissue, the question arose as to whether it might prefer decomposing hyacinth roots. Scuds were fed normal and decomposing hyacinth roots tagged with P-32. Those individuals feeding upon the decaying tissue showed 1.9 times higher radiation count.

Although omnivorous, the crayfish *Procambarus fallax* could be observed hanging from and crawling among hyacinth roots where it appeared to browse and feed directly upon the roots. The P-32 tracer evidence for the crayfish corroborated this observation.

Although the snail *Pomacea paludosa* and tadpole of *Hyla cinerea cinerea* showed a high concentration of P-32 uptake, these forms may possibly browse upon the periphyton (aufwuchs) growing on the hyacinth roots. Further study is necessary to determine the precise source of nutrition for these two species.

Carnivore Trophic Level. The majority of the organisms studied gave evidence which placed them in the carnivore feeding level. These include the freshwater shrimp (*Palaemonetes paludosus*), water scorpion (*Ranatra fusca*), an anisopteran larva, southern brown bullhead (*Ictalurus nebulosus marmoratus*), redfinned killifish (*Lucania goodei*), golden topminnow (*Fundulus chrysotus*), stumpknocker (*Lepomis punctatus punctatus*), bluegill (*Lepomis macrochirus purpurescens*), bluespotted sunfish (*Enneacanthus gloriosus*), and crappie (*Pomoxis nigromaculatus*).

In addition to each of these forms showing evidence of feeding upon the herbivorous scud, the golden topminnow feeds upon anisopteran larvae and both the bluegill and stumpknocker feed upon the freshwater shrimp.

One numerically important member of the hyacinth community is the water bug, *Belostoma* sp. No evidence was forthcoming in this study which indicated it to be either a hyacinth or scud feeder.

Summary

A study of the trophic relationships in the water hyacinth community was conducted using biota from the St. John River Drainage near DeLand, Florida, from June 16 through August 8, 1969.

The water hyacinth is a superior experimental plant for radionuclide absorption from an aqueous solution. The amphipod *Hyalella azteca* is the basic herbivore of the water hyacinth community. This species browses upon the root system of the producer hyacinth. Feeding observation and P-32 tracer studies indicate that the following species feed directly upon water hyacinth roots: *Hyalella azteca, Pomacea paludosa, Procambarus fallax,* and *Hyla cinerea cinerea* (tadpole). Feeding observation and radioisotope experimentation gave evidence that the amphipod *Hyalella azteca* serves as food for the following piscine species: *Ictalurus nebulosus marmoratus, Lepomis punctatus punctatus, Lepomis macrochirus purpurescens,* and *Enneacanthus gloriosus.* Preliminary evidence using P-32 tagged *Hyalella* indicates that the following forms feed upon the amphipod: *Palaemonetes paludosus, Procambarus fallax, Ranatra fusca,* an anisopteran larva, *Lucania goodei, Fundulus chrysotus, Mollienesia latipinna,* and *Pomoxis nigromaculatus.*

A partial food-web of the water hyacinth community, constructed as a composite from all data, shows two producers, five herbivores, and 11 carnivores.

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